WO9939476

Publication Title:

SECURE ONE-WAY AUTHENTICATION COMMUNICATION SYSTEM

Abstract:

Abstract of WO 9939476

(A1) Translate this text A protocol for authenticating at least one of a pair of first and second correspondents C and T in a data communication system, the method comprising the steps of storing a public key in the first correspondent C; computing a shared secret by the second correspondent T incorporating the public key C; storing the shared secret in the first correspondent C; the second correspondent T generating a challenge value chi ; the first correspondent C transmitting to the second correspondent T information including the stored public key C; the second correspondent T computing a test shared secret from the received public key C; the first and second correspondents computing response signals using the challenge value chi and the shared secret in a one-way function f?1?; and the first correspondent C transmitting the computed response signal to the second correspondent T whereby the second correspondent verifies the first correspondent.
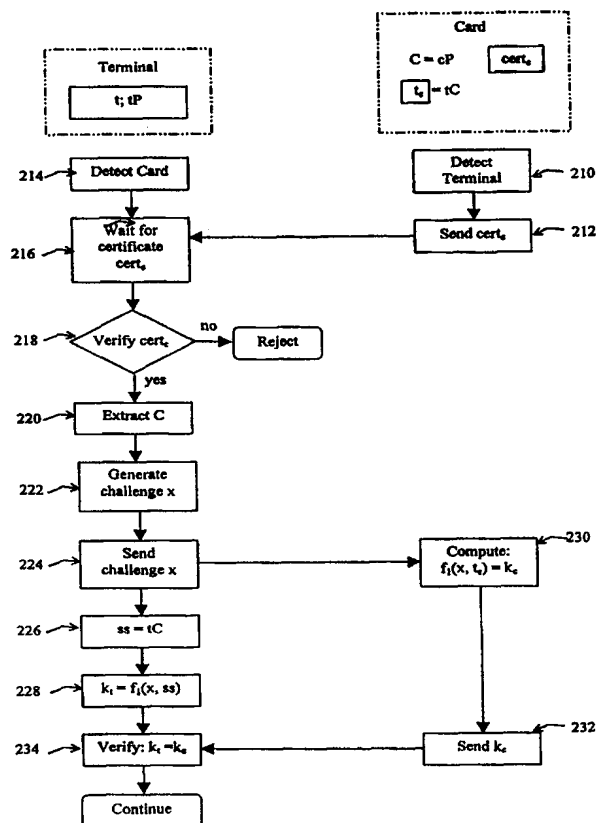
(54) Title: SECURE ONE–WAY AUTHENTICATION COMMUNICATION SYSTEM

(57) Abstract

A protocol for authenticating at least one of a pair of first and second correspondents C and T in a data communication system, the method comprising the steps of storing a public key in the first correspondent C; computing a shared secret by the second correspondent T incorporating the public key C; storing the shared secret in the first correspondent C; the second correspondent T generating a challenge value χ; the first correspondent C transmitting to the second correspondent T information including the stored public key C; the second correspondent T computing a test shared secret from the received public key C; the first and second correspondents computing response signals using the challenge value χ and the shared secret in a one–way function f_l; and the first correspondent C transmitting the computed response signal to the second correspondent T whereby the second correspondent verifies the first correspondent.

SECURE ONE-WAY AUTHENTICATION
COMMUNICATION SYSTEM

5   This invention relates to a protocol for the secure verification of
correspondents in a data communication system and in particular to the verification of
at least one of the correspondents having limited computing power.

BACKGROUND OF THE INVENTION

10   Traditionally, a mechanical turnstile system was used to restrict the entry of
persons into or out of a pre-determined area. In order to gain entry, the user is
required to pay a fee, the fee being in the form of cash, tokens, fee cards or other
payment medium. These mechanical turnstiles however allow entry without being
able to identify the persons entering or leaving. In order to monitor users, an operator

15   is required.
           In order to alleviate this problem electronic card entry and exit systems were
devised. In these types of systems, a user is issued with an identification card
beforehand which is then inserted into a card reader and upon positive verification
will allow entry via a locked door or similar barrier thus obviating the need for an

20   operator. A disadvantage of this system is that for a large number of users, a database
has to be maintained listing each of the users, particularly if each user has a unique
identification then the verification system is required to scroll through each of the
records to find a matching identity. Secondly, this system is also inconvenient if there
are a large number of users entering a particular location at a given time such as a

25   public transit way, the insertion and withdrawal of cards from a card reader is apt to
cause bottlenecks at the entrance way.
           Transit systems have been devised in which users are provided with a pre-
programmed smart card. In this system, the turnstile or a terminal is able to monitor
the smart card remotely thus the user simply walks past the turnstile without having to

30   physically insert the card in a slot. The card is generally activated by the presence of
a electromagnetic field generated by the terminal, the card then transmits an
appropriate identification back to the terminal which verifies the card identification
and allows entry of the user. These cards generally have limited computing power
and are not able to perform complex computations. It is also desirable to authenticate

35   these cards to prevent duplication or fraudulent entry. Because the cards have limited

computing power, it is necessary to implement a authentication protocol that
minimizes the computation performed by the card and furthermore is able to provide
verification of the card by the terminal in a very short period of time, generally less
than one second.

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SUMMARY OF THE INVENTION

This invention seeks to provide a solution to the problem of card verification
between a terminal and a card where the card device has limited computing power.

According to one aspect of this invention there is provided a method of

10   authenticating at least one of a pair of correspondents T and C in an information
exchange session, and wherein one of the correspondents T includes a secret key t and
the other correspondent C has a public key C and a shared secret value t_C derived
from said public key C and said secret key t the method comprising the steps of:

the first correspondent C transmitting to the second correspondent T said

15   public key C;

the second correspondent T generating a challenge value χ and transmitting
said challenge value χ to said first correspondent C;

said second correspondent T generating a session shared secret value ss by
combing said private key t with said public key C of said first correspondent C;

20   said second correspondent T generating a response test value k_t by combining
said session shared secret ss with said challenge χ, in a mathematical function f_1;

said first correspondent C generating a response value k_c by combining said
shared secret t_C with said challenge value χ in said mathematical function f_1 and
sending said response value k_c to said second correspondent T; and

25   said second correspondent T comparing said response test value k_t to said
challenge response value k_c to verify said first correspondent C.

A further aspect of this invention provides for said public key C being
included in a certificate $Cert_C$, whereby the second correspondent verifies the
certificate on C and the identity of the first correspondent C before generating the

30   challenge χ.

In accordance with a further aspect of this invention the mathematical function
f_1 is a one way function.

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a communication system; and

5   Figure 2 is a flow chart showing a verification protocol according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the following description like numerals referred to like elements. Referring
10   to figure 1, a transit control system is shown generally by numeral 10. In the system, a user 12 carries an identification card 14. A terminal including a card reader is provided for remote monitoring of card carrying users 12. The terminal 16 communicates with cards in a given area of proximity via, for example, electromagnetic means 18. These systems are readily available and will not be
15   discussed further.

In the context of the present data communication system, the card and terminal are designated a pair of first and second correspondents C and T respectively. Depending upon the reading mechanism employed, the card generally is powered when brought in proximity to the magnetic field generated by the terminal 18. The
20   card 14 contains a low power processing unit which is at least capable of performing simple calculations. In a typical data communication session, the card assembles a data string, which when assembled is transmitted to the terminal.

At system set-up, i.e. when a card is issued to a user, an encryption scheme is chosen and appropriate system parameters are defined. In the following example an
25   elliptic curve encryption scheme is used. The details of encryption schemes will not be discussed as they are well known in the art. However, if the elliptic curve encryption system is being utilized, then a public value $C = cP$, is computed where P is a generator point on the elliptic curve. The public value C is signed by a certifying authority (CA) to produce a certificate $Cert_c$, containing the public key C and
30   identification of the card C and stored in the card 14. A shared secret $t_C = tC$ is calculated where t is a secret key known to the terminal T. This shared secret t_C is stored in the card within a secure boundary. Thus after the system set-up phase, the card contains a certificate $Cert_C$ and a shared secret t_C.

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Referring now to figure 2, a protocol according to an embodiment of the present invention is shown generally by numeral 200. When the user 12 carrying the card 14 is in proximity to the terminal 18, the card detects the terminal 210 and sends its certificate $Cert_c$ to the terminal T. Similarly when the terminal detects the card 214

5   it waits for a certificate $Cert_c$ 216. When the terminal receives the certificate, it verifies the certificate using the CA's public key 218. If the certificate is not verified, a rejection signal is generated which may be used to alert or signal an appropriate barrier or event. However if the certificate is verified the terminal extracts the public key C of the card from the certificate 220. The terminal then generates a challenge χ

10   222, which may be a large integer, or any suitable bit string. This challenge χ is then sent to the card 224. At the same time the terminal computes a shared secret ss = tC and computes a challenge response verification value $k_T = f_1(\chi, ss)$, where f_1 is a one-way function such as a secure hash function or one derived from the data encryption standard (DES). The card upon receipt of the challenge χ also computes its challenge

15   response k_c by applying a one-way function f_1 to the challenge value χ and the shared secret t_C to calculate $k_c = f_1(\chi, t_C)$. This challenge response value k_c is then sent back to the terminal 232 where it is verified 234 by the terminal comparing k_t to k_c. If these values are equal then the card is verified.

It may be seen thus that the purpose of the challenge χ is to know that the card

20   has the shared secret t_C, otherwise the data communication system is open to replay attack, where an observer watches for the k_c and may send it back at a later time. Furthermore it may be seen from the system that the terminal does not have to maintain a record of secret keys for each card authorized in the system. The advantage of this may well be appreciated when for example the card is a public rail

25   transit card identification and the terminal has to maintain records for each of approximately a few hundred thousand users. Thus the present invention avoids this disadvantage.

In a further embodiment, the card may at step 230 in producing the challenge response compute a value $k_{sig} = f_1(\chi, t_c, m)$ where m is a message to be signed by the

30   card. The card may then concatenate the challenge response k_{sig} with the message and sends this to the terminal. In this instance, the card is both authenticated and a message generated by the card is signed.

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In a still further embodiment, the card may be authenticated as well as send an encrypted message. In this instance, the card calculates its challenge response value $k_{enc} = f_1(\chi, ss)$ and using this value as a key to calculate an encrypted value of a message m using for example a DES or DESX such that $E = E_{Kenc}(m)$. In this

5   instance the card is implicitly authenticated with the encrypted message. This may be useful for example when the card sends a P.I.N. back to the terminal.

In a further embodiment, the system rather than utilizing a single value of t, may use many values of t, i.e. t_i thus producing many shared secrets $ss(t_i)$. In this instance, the card will send with its certificate the index i so that the terminal may

10   extract the appropriate t_i to compute its shared secret as shown in step 226 figure 2.

In the above examples, the shared secret $ss = t_C$ was for an elliptic curve implementation. For a finite field implementation, the shared secret may be calculated as $ss = C^T$. Furthermore a more generalized form of the shared secret is a function combining the values of the terminals private key t and the cards public key

15   C using a cryptographic function $f_1(t, C)$.

While the invention has been described in connection with the specific embodiment thereof, and in a specific use various modifications thereof will occur to those skilled in the art without departing from the spirit of the invention as set forth in the appended claims. In general, this invention has application to situations where

20   authenticated access to goods and services are required or where entry is to be controlled.

The terms and expressions which have been employed in this specification are used as terms of description and not of limitations, there is no intention in the use of such terms and expressions to exclude any equivalence of the features shown and

25   described or portions thereof, but it is recognized that various modifications are possible within the scope of the claims to the invention.

WE CLAIM:

1.   A method of authenticating at least one of a pair of first and second correspondents
      C and **T** in a data communication system, said method comprising the steps of :
      storing a public key in said first correspondent **C**;
      computing a shared secret by said second correspondent T incorporating said public
      key C;
      storing said shared secret in said first correspondent **C**;
      said second correspondent **T** generating a challenge value χ;
      said first correspondent **C** transmitting to the second correspondent **T** information
      including said stored public key C;
      said second corespondent **T** computing a test shared secret from said received public
      key C;
      said first and second correspondents computing response signals using said
      challenge value χ and said shared secret in a one-way function f_1; and
      said first correspondent **C** transmitting said computed response signal to said second
      correspondent **T** whereby said second correspondent verifies said second
      correspondent.

2.   A method as defined in claim 1, including said first correspondent **C** transmitting a
      signed message *m* with said response.

3.   A method as defined in claim 2, including signing said message with said one way
      function.

4.   A method as defined in claim 3, said signed message being included with said
      computed response and concatenated with said message for transmission.

5.   A method as defined in claim 1, including said first correspondent **C** encrypting a
      message *m* in accordance with a symmetric key scheme, wherein said symmetric key
      is derived from said computed response value and transmitting said encrypted
      message to said second corespondent **T**.

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6.   A method as defined in claim 5, said signature scheme is an RSA type signature
        scheme.

7.   A method as defined in claim 1, said shared secret being computed by said second
        corespondent **T** by utilizing its secret key and the public key C.

8.   A method as defined in claim 1, said second corespondent **T** having a plurality of
        private keys t_i corresponding to respective first correspondents;
        receiving from said first correspondent **C** an identification index i ; and
        using said corresponding private key t_i and the public key C to compute a shared
        secret ss_i.

9.   A method as defined in claim 1, said public key scheme being an elliptic curve
        scheme.

10.   A method as defined in claim 1, said public key scheme being an RSA type scheme.

11.   A method of authenticating at least one of a pair of correspondents **T** and **C** in an
        information exchange session, and wherein one of the correspondents **T** includes a
        secret key t and the other correspondent **C** has a public key C and a shared secret
        value t_C derived from said public key C and said secret key t, the method comprising
        the steps of:
        the first correspondent **C** transmitting to the second correspondent **T** information
        including said public key C;
        the second correspondent **T** generating a challenge signal χ and transmitting said
        challenge signal χ to said first correspondent **C**;
        said second correspondent **T** generating a session shared secret ss by combing said
        private key t with said public key C of said first correspondent **C**;
        said second correspondent **T** generating a response signal k_t by combining said
        session shared secret ss with said challenge signal χ, in a mathematical function f_l;
        said first correspondent **C** generating a response value k_c by combining said shared
        secret t_C with said challenge value χ in said mathematical function f_l and sending
        said response value k_c to said second correspondent **T**; and

                                              7

said second correspondent **T** comparing said response test value k_t to said challenge response value k_c to verify said first correspondent **C**.

12.   An article of manufacture comprising:

a computer usable medium having computer readable program code embodied therein for authenticating at least one of a pair of correspondents **T** and **C** in an information exchange session, and wherein one of the correspondents **T** includes a secret key t and the other correspondent **C** has a public key C and a shared secret value t_C derived from said public key C and said secret key t, the computer readable program code in said article of manufacture comprising;

computer readable program code configured to cause a computer to generating a challenge signal χ and transmitting said challenge signal χ to said first correspondent **C** in response to a received public information from said first correspondent ;

computer readable program code configured to cause a computer to generating a session shared secret ss by combing said private key t with said public key C of said first correspondent **C**;

computer readable program code configured to cause a computer to generate a test response signal k_t by combining said session shared secret ss with said challenge signal χ, in a mathematical function f_1;

computer readable program code configured to cause a computer to compare said response test signal k_t to a received response value k_c from said first correspondent to verify said first correspondent **C**.
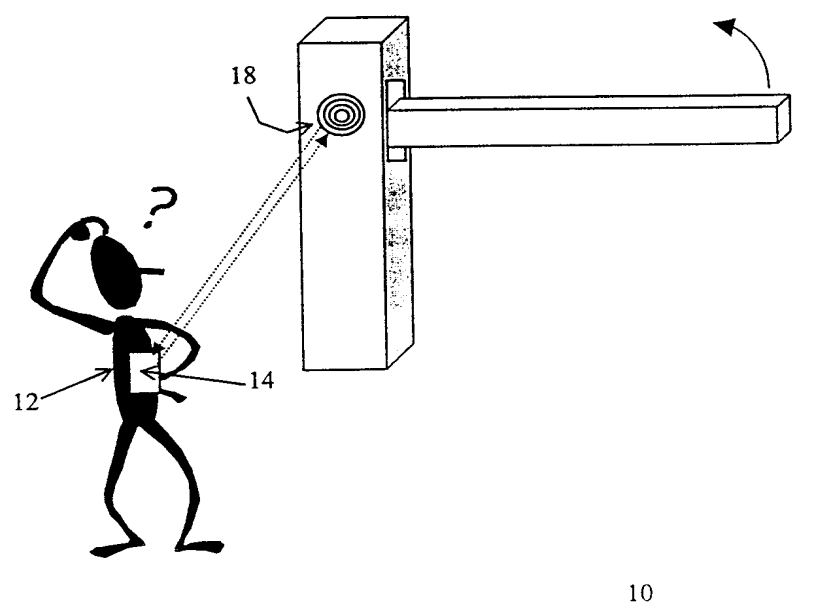
18

12

14

10

FIG. 1

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                                          ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
                                          │            Card           │
                                          │                           │
                                          │   C = cP      ┌────────┐   │
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐              │               │ certc  │   │
│         Terminal        │              │   ┌──────┐     └────────┘   │
│                         │              │   │  tc  │ = tC            │
│    ┌───────────────┐    │              │   └──────┘                 │
│    │     t; tP     │    │              └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
│    └───────────────┘    │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
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Detect Card — 214

Wait for certificate certc — 216

Detect Terminal — 210

Send certc — 212

218 — Verify certc — no → Reject

yes

220 — Extract C

222 — Generate challenge x

224 — Send challenge x

230 — Compute: $f_1(x, t_c) = k_c$

226 — ss = tC

228 — $k_t = f_1(x, ss)$

232 — Send k_c

234 — Verify: $k_t = k_c$

Continue
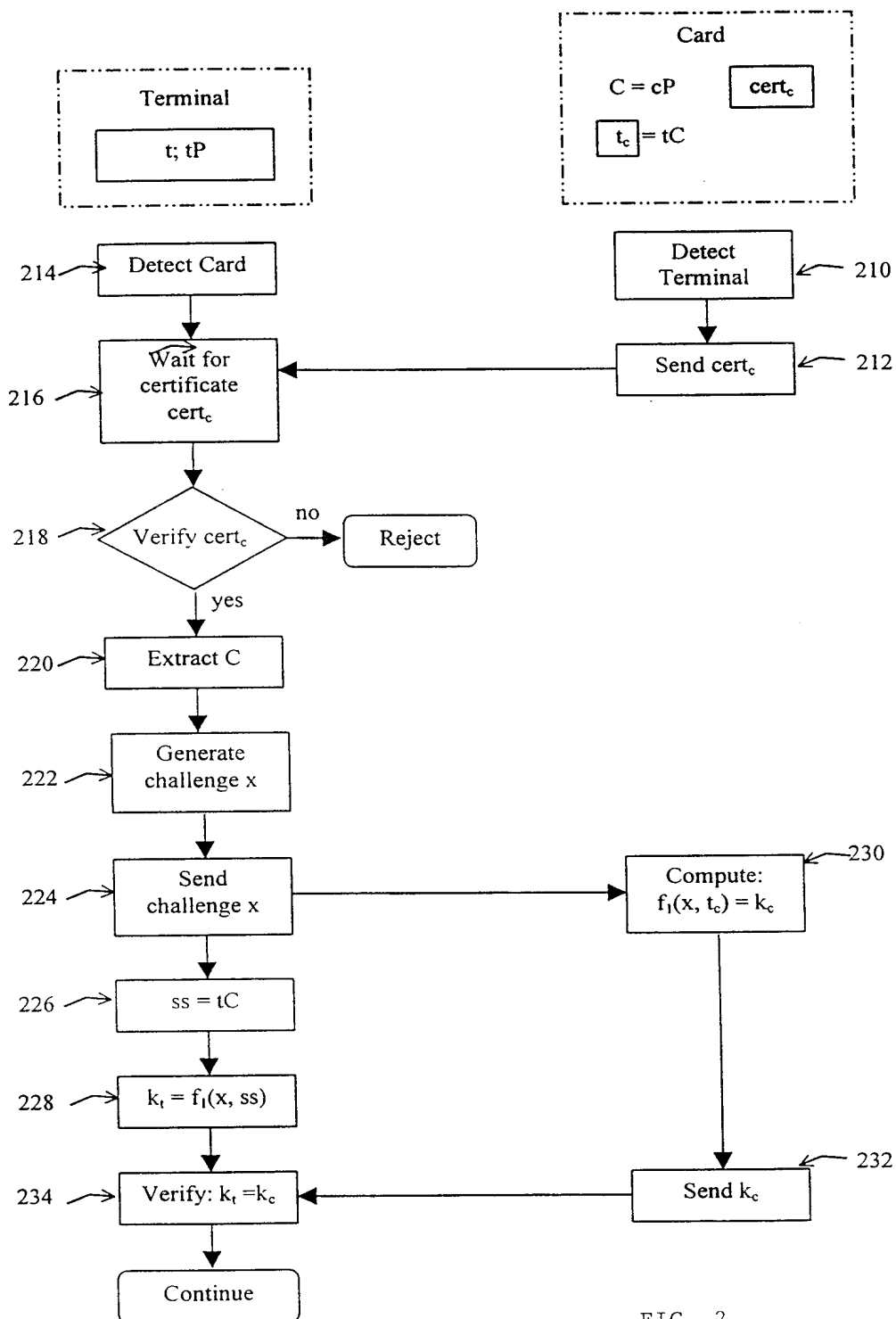
FIG. 2

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   H04L9/32   G07F7/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   H04L   G07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 535 863 A (AMERICAN TELEPHONE & TELEGRAPH) 7 April 1993	1,11
A	see abstract see page 4, line 43 – page 5, line 42 see page 6, line 20 – line 22 ---	12
A	"LIMITATIONS OF CHALLENGE–RESPONSE ENTITY AUTHENTICATION" ELECTRONICS LETTERS (STEVENAGE GB), vol. 25, no. 17, 17 August 1989, page 1195/1196 XP000054010 see the whole document -----	1,11,12

☐ Further documents are listed in the continuation of box C.   ☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 June 1999	02/07/1999

Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Holper, G

Form PCT/ISA/210 (second sheet) (July 1992)

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				AU 648433 B		21-04-1994
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